heads stored in a data base is realized by a flexible mapping mechanism, the optimum mapping being realized by an optimization method (cf. Lades et al., IEEE Transactions on Computers, 42, 300-311).

This method is, however, disadvantageous insofar as it does not seem to be suitable for processing large quantities of data. It is true that Lades et al. was able to recognize an image of a head from a data base which comprised images of 87 persons, but in many cases of use much larger reference data bases have to be reckoned with.

In addition, the method according to Lades et al. was only realized with a special hardware configuration, viz. with transputers, i.e. with a plurality of microprocessors which are interconnected in a predetermined manner.

In view of these disadvantages of the methods according to the prior art, it is the object of the present invention to improve the known methods in such a way that their robustness with respect to less optimum image data is increased in comparison with the known method, and to guarantee in addition that the method can be realized by conventional means.

Description of the invention

The above-mentioned object is achieved by a method for automatically recognizing one or more structures in digitized image data, said method comprising the steps of:

(a) providing at least one reference graph comprising digitized reference image data of corresponding reference images, the reference graph or each reference graph comprising a net-like structure, the respective net-like structure being defined in that specific reference image data have assigned thereto nodes which are interconnected by links in a predetermined manner, and jets, each node having a jet assigned thereto and each jet comprising at least one sub-jet which is determined by convolutions of at least one class of filter functions with different magnitudes and/or orientations with the reference image data of the corresponding reference image at the specific node, or by convolutions of at least one class of filter functions with different magnitudes and/or orientations with colour-segmented reference image data of the corresponding reference image at the spe-

cific node, or by colour information on the reference image data at the specific node, or by texture descriptions of the corresponding reference image at the specific node, said texture descriptions being gained by statistical methods, or by motion vectors at the specific node, said motion vectors being extracted from successive reference images,

(b) determining an optimum image graph from the digitized image data for each reference graph, said optimum image graph representing for a specific reference graph the optimum adaptation to said reference graph and being determined by projecting the net-like structure of said specific reference graph into the image data whereby the structure of the image graph is defined, and determining sub-jets of the image graph at the nodes defined by its structure, said sub-jets corresponding to at least part of the determined sub-jets of the specific reference graph, and the projection of the net-like structure of said specific reference graph being varied until a graph comparison function which compares the jets of the image graph with the corresponding jets of said specific reference graph becomes optimal,

(c) associating the structure or each structure with the reference image corresponding to the reference graph for which the graph comparison function is optimal with respect to the optimal image graph determined for said reference graph.

By means of this method it is possible to utilize image information of different qualities simultaneously, such image information being e.g. convolutions of the class/classes of filter functions with arbitrary magnitudes and/or orientations with the image data and/or convolutions of the class/classes of filter functions with arbitrary magnitudes and/or orientations with colour-segmented image data and/or colour information on the image data and/or image-data texture descriptions gained by statistical methods and/or motion vectors extracted from successive images. This has the effect that, in comparison with the prior art, an improved structure recognition rate can be realized.

In addition, a higher robustness in comparison with the methods known from the prior art can be achieved by combining image information of different qualities.

According to a further development of the present invention a plurality of reference graphs can additionally be provided, and the reference graphs which have net-like

structures that are topologically identical, i.e. which differ only with respect to the lengths of respective corresponding links, can be combined to form a reference bunch graph. Such a reference bunch graph comprises a net-like structure defined by nodes which correspond to the nodes of the reference graphs and by links which are determined by averaging the corresponding links of the reference graphs, and it further comprises bunch jets, each of said bunch jets being composed of the sub-jets corresponding to the jets at the respective nodes of the reference graphs combined in the reference bunch graph. In addition, an optimum image graph for the or for each reference bunch graph is determined according to this further development. Said optimum image graph represents for a specific reference bunch graph the optimum adaptation to said reference bunch graph and it is determined by projecting the net-like structure of said specific reference bunch graph into the image data whereby the structure of the image graph is defined, and by determining sub-jets corresponding to at least part of the sub-jets which have been used for determining the sub-jets of the reference graphs underlying the specific reference bunch graph. In addition, the projection of the net-like structure of said specific reference bunch graph is varied until a graph comparison function which compares the jets of the image graph with the corresponding bunch jets of said specific reference bunch graph becomes optimal, sub-jets of the image graph being compared with the sub-jets in the corresponding bunch jet of said specific reference bunch graph. Finally, each structure is associated with the reference image corresponding to the reference graph or to the reference graph from the reference bunch graph or graphs for which the graph comparison function is optimal with respect to the optimal image graph determined for said reference graph.

The use of reference bunch graphs permits, on the basis of the same number of reference images, an increase in the amount of structures which are available for the comparison or, in other words, a reference bunch graph permits the representation of a complex-structure object class with a small number of examples. In addition, the use of reference bunch graphs permits such structure object classes to be modelled by examples of individuals.

Depending on the respective case of use, i.e. on the structures to be recognized, only part of the reference graphs provided may be combined so as to form one or a plurality